

RMA-2 is a two-dimensional, depth averaged, finite element, hydrodynamic model that can be used to simulate hydraulic conditions in rivers, estuaries, lakes, embayments and oceans. It solves the Reynolds form of the Navier-Stokes equations for turbulent flows and allows for wetting and drying of elements. It does not model supercritical flow conditions. RMA-2 was originally developed by Resources Management Associates, and further modified by the U. S. Army Corps of Engineers, Waterways Experiment Station (WES). RMA-2 has been used over the years by both the public and private sector. The code for the model is public domain and can be obtained directly from WES. The RMA-2 model has been packaged by several software companies and can now be purchased with a pre-processor interface called FastTABS (Brigham Young University 1993) that assists in setting up the model geometry and boundary conditions. Equivalent versions of RMA-2 and a 2-D sediment model are available directly from Resource Management Associates as well as a user interface program. RMA-2 was originally developed on a CRAY computer but is now available for the PC and Unix workstation platforms.

The output from RMA-2, consisting primarily of depths and depth averaged two-dimensional flow field, is input into STUDH. STUDH is the sediment transport program of the TABS-2 package and uses the same mesh or grid defining the channel geometry as RMA-2. The STUDH model solves the convection-diffusion equation with bed source terms, and allows one sand layer or up to 10 layers of cohesive sediment at each node for maintaining separate material types, deposit thickness, and age. The STUDH model is structured for either sand or cohesive sediments, but not both. STUDH can simulate the net erosion and deposition but cannot be used to trace the movement of sediments. STUDH only allows the use of one representative grain size (D50) for each soil type.

WES has supplied the following computer code and manuals through the EPA:

- C RMA-2 Computer Code revised August 1988, RMA-2 Documentation Draft
Copy dated February 1994
- C ENGMET Computer Code revised January 1989, ENGMET Documentation
dated April 1985
- C STUDH Computer Code revised November 1990, STUDH Documentation dated
April 1985
- C Miscellaneous computer and data transfer programs with various dates

WES has written several transfer programs to allow the output from STUDH to be viewed in the post-processor FastTABS.

The STUDH model is not publicly supported by WES. However, WES has provided some training in the use of the TABS-2 models. The EPA has stated in the conference call conducted on December 8, 1994 that the models have been successfully applied in many comparable studies.

7.3 MODEL PLAN AND APPROACH

To achieve the objectives of the sediment mobility investigation, several terms and requirements need to be defined. This section provides an overview of the modeling process. The technical steps necessary to perform the modeling required are described in later sections.

A summary of the activities that must be accomplished to utilize the WES TABS-2 package and to address the EPA's sediment mobility goal for the Passaic River Study Area are as follows:

- C Convert TABS-2 model code to a suitable project oriented computer platform
- C Test converted model code and computer platform with a test case provided by WES
- C Prepare model code test case report
- C Submit model code test case report on useability of model code for review and comment
- C Collect field data in the Passaic River Study Area for hydraulic and sediment transport model calibration/verification
- C Assimilate appropriate field data collected for the USACE Model Study of Newark Bay into the Passaic River Study.
- C Transfer recorded flow and tidal data to the Passaic River Study Area model boundaries
- C Utilize USACE model results of Newark Bay and/or relationships between hydrodynamic conditions and sediment transport from the USACE model results in development of downstream boundary conditions for the sediment transport modeling of the Passaic River.

- C Setup and simulate hydraulic model for present and past conditions
- C Setup and simulate sediment transport model for present and past conditions
- C Prepare calibration/verification report
- C Submit calibration/verification report on reliability of sediment mobility modeling for review and comment
- C Develop stressed event hydrology and tidal event
- C Setup and simulate hydraulic model for stressed future event
- C Setup and simulate sediment transport model for stressed future event
- C Evaluate reliability of modeling results

WES is currently running the TABS-2 package on several different computer platforms. The RMA-2 and STUDH programs with the pre- and post-processor FastTABS can be currently run on several Unix based workstations and the PC. The EPA has indicated in the conference call conducted on December 8, 1994, that the software can be relatively easily installed on several alternative computer platforms and can be purchased at a cost competitive with user costs on a commercial system. The EPA also indicated in the conference call conducted on December 8, 1994, that the model has successfully been run on computer platforms of a speed no greater than a current 486 or Pentium PC, and that the STUDH program has been compiled with no difficulty on several Unix-workstations and is currently being ported to a PC. Presently, the STUDH program is only being run on the WES Cray computer. One of the main issues with running

RMA-2 on a different platform than that used for STUDH is the output from RMA-2 is used as input into STUDH. The volume of output data produced by RMA-2 is so large the output file has to be binary, and different platforms and operating systems have different binary files. Thus, platform transfer programs must be written to transfer data between the programs and platforms. In addition, RMA-2 uses English units and STUDH uses metric units. Therefore, a program which converts the units between the programs is needed. This transfer program has been developed by WES for their computer platforms and may need to be modified for other platforms. Supporting documentation must be developed for all of the transfer programs.

Based on a meeting with Joe Letter at WES on April 26 and 27, 1994 concerning the TABS-2 computer package received from WES, the following items need to be considered. The entire TABS-2 package is not available on an easily accessed computer platform. Cray computer time is not easily obtained by private organizations because of computer time priority and computer cost. Cray computers have been typically used by research and government organizations and when private organizations are allowed to purchase Cray computer time, their priority for obtaining computer time is below those individuals who are doing research. Thus, the turn around time for reviewing results is the simulation time plus queue time waiting for computer space to become available. The queue time can be difficult to predict. An alternative platform (i.e., Unix-based, Pentium PC) should be used to meet the requirements of a strict schedule oriented project.

Timely computer simulations are necessary to meet the stipulated timeframe in the AOC. The computer code will need to be compiled onto a platform to suit the needs of the sediment mobility task. To address this objective in a reasonable and expert manner, the code will be modified and compiled, test cases which have previously been run by WES will need to be simulated on the chosen computer platform to demonstrate that the modified and compiled code will match that run by WES on their platform.

A Unix based machine is preferable, if the test case is successful, because the computer accessibility can be controlled and therefore simulation time can be reasonably estimated. If a Cray computer platform is required, queue time is unknown, may prove to be significant, and could prohibit adherence to the schedule. STUDH and RMA-2 will be run on a machine with greater than 16 bit precision. Close attention to numerical precision will be paid.

Upon completion of the code modification and test runs, a report on the useability of the model code in meeting project needs will be submitted for review and comment in accordance with the schedule in Section 10.0 of this IWP.

The field data to be collected to support the calibration/verification of the computer models are explained in Section 3.3 and 3.4 of the FSP.

To define the upstream hydraulic model boundary, the upstream recorded USGS flow record at the Little Falls Gage will be transferred to the upstream end of the model boundary. The transfer is described in Section 7.5.3. To define the downstream hydraulic model boundary the recorded NOAA tidal gage data will be transferred to the downstream model boundary. The transfer process is described in Section 7.5.4.

Following the successful completion of the WES TABS-2 test case analysis, normal condition simulations for analysis of present sediment migration pathways will be performed as described in detail in Section 7.6 using the new bathymetry data to be collected under this RIWP, and the flow, velocity and suspended and bed load sediment data to be collected under this RIWP as described in Section 3.3 of the FSP. This will serve as a calibration run to demonstrate that the RMA-2 and STUDH models can be calibrated and simulate observed conditions over at least one tidal cycle.

As described in Section 7.7, a past condition simulation for the period 1986-1989 will be used as the overall verification for the model. The input to RMA-2 for this simulation will be a mesh developed from the 1986 bathymetry and the period of flow and tide record between 1986 and 1989. The flow and tide data will be continuous if feasible based on the computational efficiency of running STUDH on the selected platform. Otherwise, a representative hydrograph for that time period will be developed. The model geometry will be confined to the channel (not including over bank flow) for this simulation, to reduce the number of computational nodes and the simulation time of the model. STUDH will be used to simulate sediment transport from 1986 through 1989. The input will be simulated velocities at each node from RMA-2 and the 1986 bathymetry. The output from this simulation will be the simulated 1989 node elevations, which will be compared to the recorded 1989 bathymetric surface at the same node locations.

Following completion of the verification simulations, a Calibration and Verification Status Report will be prepared and submitted to EPA with an evaluation of the accuracy and reliability associated with the sediment mobility modeling.

A stressed condition simulation for analysis of future sediment migration pathways will be performed using the new bathymetry and stressed river hydraulic conditions. The stressed condition will correspond to the estimated 100-year event. The 100-year event was selected because it is the most common standard for evaluation of low probability significant events. This provides adequate information for the interpretation of modeling results for use in completing the FS.

7.4 MODEL CODE TEST CASE REPORT

The Model Code Test Case Report will be submitted to EPA for review and comment. If necessary, meetings or conference calls will be scheduled with WES and EPA in order to resolve any comments. When modifications to a computer code are made in order for a model to work on a given platform, the modified code must be checked against simulations on the original computer code and platform combination to confirm that the

modifications are appropriate. In this case, this is primarily due to the fact that the computer architecture of the Cray is significantly different than the computer architecture of a Unix based machine. If the computer code cannot be converted successfully, the Model Code Test Case Report will provide a description of the efforts utilized in the attempted conversion, a description of potential impact to the RIWP work, and will identify necessary modifications to the RIWP requirements and RI/FS schedule.

7.5 MODEL SETUP

7.5.1 Finite Element Mesh

Based on modeling judgement, the bathymetry data will be reduced to point estimates of depth, called a mesh, throughout the Passaic River Study Area. All elevations will be referenced to the National Geodetic Vertical Datum. These point estimates correspond to nodes in the model set-up and represent a given area in the model. Model elements are composed of 6 to 8 interconnected nodes.

The first step of the model set-up is to generate the finite element mesh. Generating a geometrically consistent mesh is very important in getting RMA-2 and STUDH to converge to a numerically acceptable solution. The pre-processor FastTABS will be used to create the mesh. RMA-2 and STUDH will utilize the same generated geometric mesh. FastTABS will read bathymetric data in ASCII format and from these data generate the elements composing the mesh automatically. Refinement of the mesh, if necessary, will be accomplished manually using FastTABS.

Three finite element meshes will be necessary to adequately perform all simulations, one each for the past, present, and future conditions. The past condition mesh will use bathymetric data for 1986 with all of the nodes located within the channel. For the

present and future condition simulations, the new bathymetric data collected as specified in the FSP Section 3.2 will be used with nodes extending above the 100-year floodplain for the future conditions. The USACE digital contour map dated January 5, 1990 will be used to develop the mesh for areas outside the channel for the future condition simulation. The locations and dimensions of the bridge piers for all simulations will be taken from as-built plans and included as high points in the model representation of the system.

7.5.2 Model Boundaries

The boundary conditions needed for RMA-2 are tide elevations versus time at the downstream boundary (see Figure 5-1) and the inflow hydrograph at the upstream boundary (see Figure 2-1). The tide elevation versus time will be specific to each calibration, verification and production run, and similarly, the inflow hydrograph at Dundee Dam will also be specific to each run.

The Hydraulic Model Area will extend above the Passaic River Study Area to a point beyond the tidal influence of Newark Bay. This is necessary to achieve model stability at the boundaries of the Passaic River Study Area and to transfer the upstream flows to a point in the river which has a unique stage-discharge relationship. The point on the Passaic River which is out of the tidal influence is Dundee Dam which will be used as the upper boundary of the Hydraulic Model Area. The mesh generated outside the Passaic River Study Area will be less detailed than the mesh inside of the Passaic River Study Area to reduce the computational effort. Increasing the mesh size outside of the Passaic River Study Area should not compromise the model stability at the Passaic River Study Area boundary providing the mesh size expands gradually.

The downstream end of the Hydraulic Model Area will extend approximately 2,100 feet downstream from the south end of the Passaic River Study Area as shown on Figure 5-1.

The downstream boundary was extended downstream in order to provide the model sufficient space to adjust the hydraulic and sediment mechanisms from the boundary of the Hydraulic Model Area to the Passaic River Study Area.

As mentioned above, a finer mesh will be used for the reaches located inside the Site than for the area located outside the Passaic River Study Area. Based upon preliminary inspection of bathymetry surveys, grid cells of approximately 150 feet x 150 feet should be adequate for the Passaic River Study Area, expanding into larger grid cells outside the Passaic River Study Area. Areas outside the river bank will also be included in the mesh for the future-stressed condition simulation. The FEMA 100-year floodplain maps, which are the best available floodplain information, show flooding potential outside of the channel banks. The floodplain width changes throughout the Passaic River Study Area. Generally, the floodplain ranges from several hundred feet to several thousand feet outside of the channel banks.

The STUDH upstream model boundary will be approximately 5,000 feet upstream from the Passaic River Study Area and the downstream boundary will be approximately 2,100 feet downstream from the Passaic River Study Area. The downstream boundary for STUDH will be the same as the RMA-2 model. The upstream boundary for STUDH will not have to extend upstream as far as the RMA-2 model to achieve stable boundary conditions.

At the downstream boundary, a relationship between sediment transport and hydrodynamic conditions will be developed. Development of the downstream boundary condition would specifically include pertinent and available data collected as specified in Section 3.3 of the FSP for this study, similar types of data collected by the USACE as part of their study of Newark Bay in the vicinity of the downstream boundary for this modeling work, as well as relationships developed between sediment transport and hydrodynamic conditions at the downstream boundary specified above based on output

and results of the USACE modeling work conducted in the area including the Passaic River and Newark Bay. If the USACE data and modeling results are provided to OCC, they will be incorporated into the modeling effort. Early receipt of this information will provide the greatest utility. Potential impact to the RIWP work and modifications to the RIWP requirements and RI/FS schedule will only be addressed if this information becomes available after the completion of the field follow-up programs (approximately 14 months after approval of the RIWP). By using all available and pertinent data collected in the field, the best available and most complete data set will be incorporated. By incorporating the USACE results from their modeling of the lower Passaic and Newark Bay, the periodic reversals of sediment transport and the dynamic conditions relating to sediment transport and hydrodynamic conditions in the lower Passaic and Newark Bay will also be included in the development of the downstream boundary condition for this modeling analysis. A progress meeting among the parties will be scheduled prior to utilization of the model to discuss the downstream modeling boundary condition developed based on inclusion of the furnished USACE field data and USACE modeling work.

7.5.3 Hydrologic Input

The purpose for estimating the flow at the upstream end of the Hydraulic Model Area is to develop inputs for the verification of past and future condition simulations. The upstream boundary condition for the RMA-2 model will be the flow from the upstream watershed at the Dundee Dam. The nearest long term flow gage is a USGS stream gage located at Little Falls, New Jersey. The gage is located approximately 13 miles upstream from Dundee Dam, the upstream Hydraulic Model Area limit. The difference in drainage area between the Little Falls gage and Dundee Dam is approximately 51 square miles. The entire flow record from 1898 to present will be transferred to Dundee Dam for statistical purposes.

To account for the difference in additional drainage area a statistical regression model will be developed. The statistical model developed will provide the flow-drainage area relationship for estimating the additional streamflow to Dundee Dam.

To account for the additional drainage area between Dundee Dam and the mouth of the River the same regression equation developed above may be used if the land use of the additional area is similar (i.e., urban area). Otherwise, a second regression equation will need to be developed. The flows will be added to the model as point flows. The point flows will be added at the confluences of the various tributaries to the Lower Passaic River.

Development of the 100-year event in a tidally influenced river requires a statistical process which includes the upstream flow and the downstream tide. Conventional techniques for estimating flood frequency are invalid in a tidally influenced reach because there is not a unique relationship between stage and flow. Probability distributions will be developed for both the flow and the tide and their joint probability distribution will be used to develop the combined 100-year event. A sensitivity analysis will be performed to evaluate the reliability of the 100-year event estimate.

7.5.4 Tidal Input

The downstream boundary condition for RMA-2 will be controlled by the tides. To define this boundary of the Hydraulic Model Area, a long-term tide gage record is necessary to develop a statistical relationship. In addition, a tide gage record for the period from 1986-1989 is necessary for predicting the past timeframe (model verification simulation) (Section 7.7).

The nearest long term continuous tide recording gage is The Battery gage in New York, New York. The gage data will be acquired and any missing data will be filled in, based

on computerized harmonic analysis tide algorithms developed by the U.S. Department of Commerce, NOAA. Missing data are data that were not collected or published by NOAA. The data will be transferred to the downstream boundary by applying the tidal difference constant established by NOAA between The Battery and the downstream boundary of the model.

7.5.5 Model Variables

Each element of the RMA-2 finite element mesh requires a Manning's 'n' roughness coefficient and the turbulent exchange coefficients (E_x , E_y , E_{xy} , E_{yx}). These variables are estimated from literature values based on field observation. These variables are adjusted during calibration because they cannot be directly measured.

STUDH input allows up to 10 layers of cohesive sediment at each node. For each layer the grain size, thickness, submerged density, cohesiveness, shear strength and erosion rate are required as input data. These parameters will be measured at 33 locations within the Sediment Transport Model Area. The collection and analysis of these parameters are specified in Sections 3.1 and 3.4 of the FSP. The geotechnical cores will be collected to a depth equivalent to the depths of cores to be taken for chemical characterization. These estimated depths are specified in Table 3-3 of the FSP.

The longitudinal and lateral effective diffusion variables (E_x' and E_y') for each element in STUDH and the initial concentration of suspended and bed load sediments at each node are also required input. The effective diffusion variables may be refined during calibration because these parameters cannot be directly measured. The initial suspended and bed load concentrations may be different for the past condition simulations (1986 bathymetry) and the normal and stressed condition simulations. These concentrations will be estimated from suspended and bed load sediment data to be collected as described in Section 3.3 of the FSP.

The STUDH model input parameters will be defined at each node. Model output consists of velocity at each node for RMA-2, and bed elevation and suspended and bed load sediment concentrations at each node for STUDH.

7.6 PRESENT TIMEFRAME - NORMAL CONDITION (MODEL CALIBRATION)

The objective of the normal timeframe and present condition (model calibration) simulation is to predict the sediment mobility for the normal event and to calibrate the RMA-2 and STUDH. The normal event can be described as a flow condition with a seasonal base flow and normal tidal ranges. It is anticipated that this normal condition will be collected during the initial field data collection and sampling program as specified in Section 3.3 of the FSP. Data defining the boundary conditions for RMA-2 both upstream and downstream will be collected as specified in Section 3.3 of the FSP. This calibration will be based on the first set of field data collected.

Initial conditions for STUDH will include a series of model runs to achieve quasi-equilibrium between the initial bed structure, shear stresses, and the suspended sediment concentration field. The temporal relationship of exchange between the bed and the flow field over the tidal cycle will be modeled. Since the sediment mobility is modeled under normal conditions, the sediment migration simulation will cover approximately 4 full tidal cycles for both models. This is in addition to the model runs used for initializing RMA-2 and STUDH. The geotechnical data to be collected during this period will be snapshots not continuous data collection at each of the cross sections defined in Section 3.3 in the FSP.

RMA-2 will be calibrated by adjusting Manning's 'n' and turbulent diffusion coefficients of the various elements to reproduce measured field data. RMA-2 will be calibrated to velocity and water surface elevations collected as specified in Section 3.3 of the FSP. Velocity in each direction (x,y,z) will be measured in real time at eight cross sections in

the Sediment Transport Model Area using the Acoustic Doppler Current Profiler (ADCP). Manning's 'n' and the turbulent diffusion coefficients will be adjusted to provide the best fit to field measurements at each cross-section.

STUDH will be calibrated by adjusting dispersion coefficients, and settling velocities to reproduce field-measured suspended and bed load sediment concentrations at the nodes. STUDH will be calibrated with suspended and bed load sediment data collected at eight locations as specified in Section 3.3 in the FSP. The longitudinal and lateral dispersion coefficients of STUDH will be adjusted to provide the best fit to measured suspended and bed load sediment concentrations calculated from the field data. The same cross sections used for the RMA-2 calibration will be used for the STUDH calibration.

7.7 PAST TIMEFRAME (MODEL VERIFICATION)

The models will be run simulating the time period from 1986 to 1989 for model verification. Both models will start with the 1986 bathymetry. The upstream flow and the downstream tide for this period will be input into the calibrated RMA-2 model. Continuous flow and tide data will be used if it is feasible. Otherwise, representative hydrology from this time period will be used. This will include consideration of the spring, neap, and mean tide. The simulated velocities from the calibrated RMA-2 model will be input into the calibrated STUDH model. The calibrated STUDH model will simulate the sediment transport from 1986 to 1989. The accuracy and reliability of the model results based on process-related and historic data (bathymetry, radiochemistry, etc.) will be documented in the Calibration and Verification Status Report.

7.8 CALIBRATION AND VERIFICATION STATUS REPORT

A Hydraulic and Sediment Transport Modeling Calibration and Verification Status Report will be prepared following the verification runs in accordance with the schedule

contained in Section 10.0. Results of the calibration and verification of RMA-2 and STUDH will be summarized in this report which will address methodology, results and conclusions regarding the degree of accuracy and reliability of the calibration and verification process. Plots of model-predicted versus measured average velocities and water surface elevation at the selected river cross-sections will be presented. The STUDH model calibration and verification evaluations will include the reliability of the sediment mobility estimates based on consistency with regard to specific chemical constituent distribution, bathymetry matches, radiochemical age dating of sediments and measured river velocities collected during the RI investigation. Based on the verification simulation discussed in Section 7.7, the accuracy and reliability in the calibration and verification of the models will be presented.

This report will be submitted to the EPA for review and comment. A meeting will be held with EPA and WES to discuss the report and conclusions in order to resolve any comments. If the sediment modeling cannot be proven to be reliable in predicting the sediment transport within the Passaic River Study Area, bathymetry in conjunction with radiodating will be used to evaluate the sediment mobility within the Passaic River Study Area and necessary modification to the RIWP and to the RI/FS schedule will be identified.

7.9 FUTURE TIMEFRAME - STRESSED CONDITION

The future timeframe, stressed conditions sediment migration modeling will be based on the 100-year event. The technical process for developing the 100-year event is described in section 7.5.3 Hydrologic Input. This single event will be simulated with both RMA-2 and STUDH to estimate the sediment transport during the event. The mesh for this event will include the overbank areas. Any channel improvements that will significantly modify the channel within the boundaries of the Sediment Transport Model Area and are authorized by the Corps of Engineers and planned for construction will be included

in the river channel geometry input data. This determination will be made prior to setting up the model for the future-stressed condition. The elevations to define the overbank area will be collected from the USACE digital topography maps dated January 5, 1990. The bathymetry input for the starting conditions for both models will be the current bathymetry collected as specified in the FSP. A calibration run will be included if an extreme flood event with flow in the overbank areas occurs and if such data were made available by EPA. In the absence of such data, this task cannot be performed. Modifications to the schedule will be addressed only if these data become available after the modeling of the future, stressed condition has begun.

The flows and tides for the RMA-2 model will be determined statistically as discussed in section 7.5.3 Hydrologic Input. The 100-year event simulation period is anticipated to cover only a few days and RMA-2 and STUDH can and will be run continuously for this period of time.

Input conditions for STUDH will be estimated from suspended and bed load sediment data collected in Section 3.3 of the FSP. Suspended and bed load sediment concentrations at the boundaries of the Passaic River Study Area will be developed based on extrapolating field measurements. The flow/tide relationship versus suspended and bed load sediment concentrations will be plotted so that suspended and bed load concentration for the higher flow/tides can be extrapolated. The input conditions for the stressed conditions will be developed by extrapolating the measured data collected in Section 3.3 in the FSP.

Because the stressed event results cannot be directly compared to measured values, professional judgement will be used to evaluate the reliability of the results. The results of the simulation and evaluation of the confidence in the results of the models will be presented in the RI Report.

8.0

EVALUATION OF THE USEABILITY OF HISTORIC BATHYMETRIC SURVEY DATA

In accordance with SOW Section B.3.a.iv, this section provides an evaluation of the usability of historic bathymetry data for the Passaic River Study Area (Site). This section reviews the criteria on which the historic bathymetry were evaluated and the results of the evaluation. The bathymetry provides the best resource to use for calibration of sediment mobility modeling and for selection of time stratigraphic intervals for chemical characterization.

8.1 OVERVIEW OF BATHYMETRIC SURVEYS

The Passaic River, Hackensack River and Newark Bay have been used for barge and boat traffic for many years; hence navigation lanes have been maintained. USACE is responsible for keeping the lanes dredged to specified project depths. One use of bathymetry by the USACE is to indicate the condition of the river and hence the amount of sediment that needs to be periodically dredged. Bathymetry data are also available for some time periods when the river was not to be dredged. Specifically, bathymetric surveys estimate the depth of water in a waterway by collecting depth measurements and horizontal control data.

Historical bathymetric surveys are available for the Site and were obtained from the USACE - New York District. The USACE stores each bathymetric survey sheet on aperture cards. An aperture card is a fiche-like storage device that contains the image of a bathymetric survey sheet which can be read by a large copier-type printer. The copies produced by the printer are not to the original scale and were enlarged to the scale indicated on the original bathymetric survey sheet.

8.2 CRITERIA FOR EVALUATING BATHYMETRIC SURVEYS

Bathymetric survey sheets containing depth information in the vicinity of the lower Passaic River were reviewed for usefulness. The bathymetry sheets were evaluated based on the following criteria:

- a clear, readable copy from the USACE¹
- clearly defined datum planes
- good survey coverage (i.e., density of survey lines no more than 250 feet apart for a given survey)
- a scale suitable for digitization

A final selection of the 79 survey sheets, based upon the criteria described above, is discussed in more detail in Section 8.3.

8.3 PASSAIC RIVER STUDY AREA COVERAGE

A total of 373 bathymetric survey sheets for the lower Passaic River were obtained from the USACE. An inventory of all sheets received is presented in Appendix B (Table B-1). Included within this table are also survey location information, whether or not it passed the selection criteria given in Section 8.2, and the reason for failure to pass (if pertinent). Some of these sheets were base maps or range maps and did not include any

¹A clear copy could not always be obtained. The USACE stores historical bathymetric surveys on an aperture card (fiche). These cards must be read and paper copies generated in a unique printer. The subsequent copy must then be enlarged to the appropriate scale. If the original aperture card image is questionable, the generated image from the printer may not be readable.

sounding (depth of water) information. These sheets were eliminated from consideration as not providing good survey coverage. An area of interest was selected which represents the area to be modeled in the sediment mobility evaluation (Section 7.0) and encompassed the Passaic River Study Area plus one mile upstream of the upstream boundary. The bathymetry data will be used for calibration and verification of sediment modeling results. The sheets which did not contain bathymetric data within this area were eliminated from consideration as not being relevant to the work to be conducted under this RIWP. Of the 150 sheets which were considered as being relevant to the work, 26 sheets were eliminated for failure to meet one or more of the criteria specified in Section 8.2, leaving 124 sheets as being considered to be useable in meeting the objectives of the RIWP. These sheets are denoted as "A" for the Class of Map column in Table B-1.

Bathymetric survey data were used in preparing this RIWP was in selecting time stratigraphic intervals to be utilized in determining sampling intervals for use in the chemical characterization of the sediments (Section 5.0). Since most of the Passaic River Study Area was dredged in 1949, and since the earliest sediments of interest in the sediment characterization are those from the 1940s, only surveys that were performed subsequent to the 1949 dredging event were selected for use in evaluation of the sedimentation history within the Site boundaries. Of the 124 sheets considered as useable, 79 represented post-1949 dredging surveys. These 79 sheets are summarized in Table 8-1 as a function of the year that the survey coverage was obtained. Figure 8-1 presents a graphical summary of the survey coverage represented by these sheets. The lower 7000 feet of the Passaic River Study Area was dredged as recently as 1983. As such, for this area only post dredging surveys were selected for use in delineating time stratigraphic intervals as detailed in Section 5.2.3.2. These were the surveys conducted in 1986, and 1989. For the rest of the Passaic River Study Area, the most recent dredging was in 1949. Of the post dredging surveys conducted within this portion of the Passaic River Study Area, five surveys were selected as providing the most complete